An Interactive MR System with Image Splitter 3D Display

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Abstract

Mixed-Reality (MR) is remarkable in many fields and Head-Mounted-Display (HMD) is considered as the main device for MR now. We propose that MR will be accomplished by using the stereoscopic display without glasses as well as HMD. We have developed a high performance stereoscopic display using our original Image Splitter which can provide left and right images to both eyes without special glasses. And we have applied this 3-D display to a Mixed Reality field. And we have attached the haptic device for our system. Operators can interact the virtual object by a real object easily with tactile feedback. This system will be suitable to training simulator system for example surgical simulator, aircraft maintenance simulator, industrial machine repair simulator and so on. This system will create the new training environment we can handle the various virtual situation with real tools in our own hand.

Key words: Image Splitter, Mixed Reality, force feed back, SPIDAR

1. Introduction

Recently, Mixed-Reality (MR) is remarkable in many fields, such as medical, games, multimedia, and attractions for the various events. MR technique is the concept that includes Augmented Reality (AR) and Augmented Virtuality(AV).[1][2] AR is to augment the real world by electrical virtual information, and AV is to augment the virtual world by real information. But the boundary between AR and AV is not defined accurately. MR is to create the new world combining the real and virtual world. Therefore the display we can see the real and virtual world is necessary for MR technique. Although we can use the various type of display for MR, Head-Mounted-Display (HMD) is considered as the main device for MR now. However most of the users feels that HMD is not comfortable, because it is too tight or too heavy.
We propose that MR will be accomplished by using the stereoscopic display without glasses as well as HMD.

We have developed a new high performance stereoscopic LC display (XGA3-D display) using our original Image Splitter™, which does not require special glasses to achieve a 3-D effect.[3] We have developed a prototype of virtual reality system with this 3-D display. Furthermore, we have applied our virtual reality system to a Mixed-Reality system.[4]

With our system, operator can interact the virtual objects by a real tool in our own hand easily. And it can provide us the tactile sensation by force feedback system.

2. 3D display with Image Splitter

2.1 Image Splitter 3-D display

Fig.1 shows the principle of the Image Splitter 3-D Display.[5] An optical filter named Image Splitter is composed by glass plate and covered by absorbent coat and it is attached on both face of the LC panel. The backlight side splitter is the high-reflection type and the viewer-side one is made of a low-reflection layer. The images on the LC panel are efficiently separated into right eye and left eye images by Image Splitter. It has an aperture for each two pixels and designed to provide the right and left eye image for both eyes through these apertures. A set of 3-D images are displayed on alternate columns of LCD. Observers can recognize the 3-D images without special glasses.

When the viewer is in the center position of the display, each eye perceives only one image without special glasses and then viewer recognize them as the stereoscopic images. In this principle, we use the double image splitter (splitter 1 and splitter 2) for the purpose of improving the quality of 3D-image, that is removing the moire or crosstalk which are peculiar problems to stereoscopic displays with no special glasses.

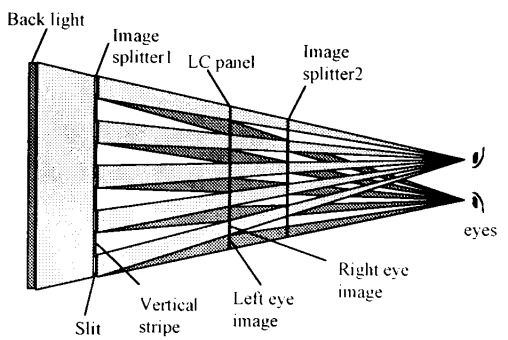

Fig. 1 Principle of Image Splitter

2.2 Characteristic of the Image Splitter

As Fig.2 shows the characteristic of the Image Splitter, the position 1 is at the front of display and it can provide us the normal stereoscopic image and it is the same with the position 3. But in case of the position 2, 4, the right eye image comes into left eye, and left eye image comes into right eye. This phenomenon is called pseudoscopic. When this phenomenon occurs, the observer can not see 3-D images.

Furthermore, the observers will view the display from different angles, but the display shows the only one pair parallax image for both eyes. So observers can not move their head in front of the display. When they interact the virtual object by a mouse or a joystick, they can not move their head or body. This causes the lack of the reality.

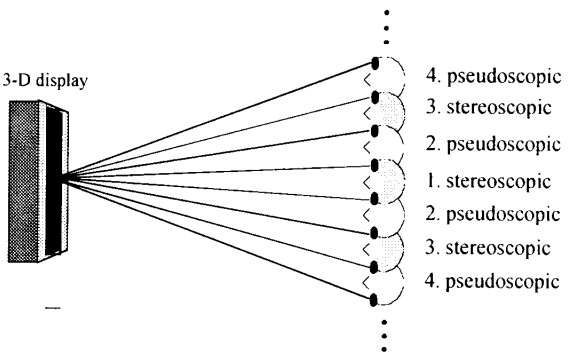

Fig. 2 The Characteristic of the Image Splitter

2.3 Head Tracking System

This display is equipped with the Head-Tracking-Sensor to prevent the pseudoscopic (Fig.3). This sensor detects the position of the observer's head (viewpoint) and sends the signal to the image switching circuit. In case of the position 1, 3 in the Fig.2, the display shows the each images to both eyes. But in case of position 2, 4 in the Fig.2, the circuit switches these images to show to inverse eyes. As a result the display shows the images for both eyes without pseudoscopic.

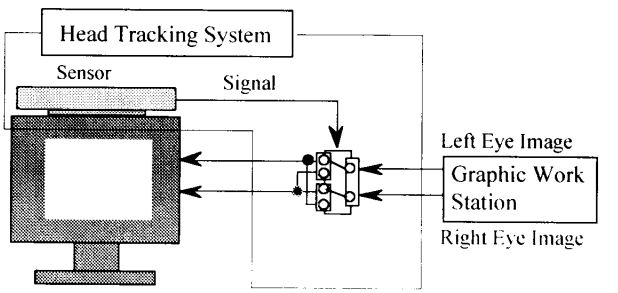

Fig. 3 Head Tracking System

2.4 High Resolution

We had developed a 4, 6, 10 inch Image Splitter 3-D displays. The resolution provided to each eye is about half a NTSC resolution. We developed a new high performance 14.5inch 3-D display (XGA 3-D display) with high resolution about NTSC for each eye. In addition, by optimizing the aperture ratio of the Image Splitters, we have achieved a moire-less autostereoscopic display. Table 1 describes the specification of the Image Splitter 3-D display. And Fig. 4 shows the XGA 3-D display.

SPIDAR is the force feedback system and composed by the frames, strings, motors and rotary encoders.[6] Strings are centralized from vertexes of the frames where the motors equipped. To roll up the strings by the motors, SPIDAR generates the force and tactile sense.

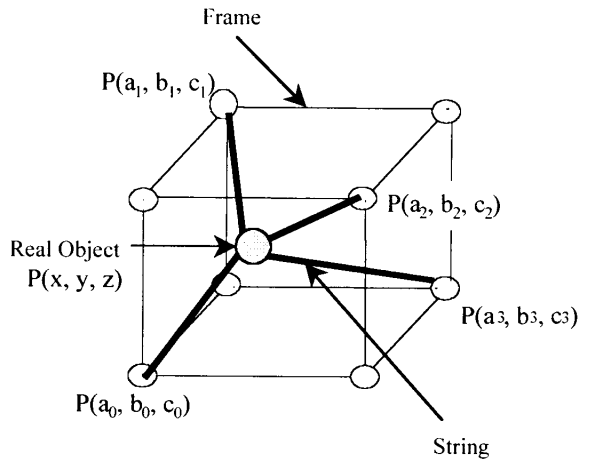

Fig. 7 SPIDAR

The rotary encoder determines the coordinate of the pointer by detecting the variety of the string. To add the initial value and variety of the string cumulatively, it can get the string length. From these equations, the coordinate of the pointer (x, y, z) is determined. As illustrated in Fig.7, The coordinate of the four vertexes are (a_i, b_i, c_i) (i = 0~3), and the length of the string is l_i(i = 0~3). From the following equations, the coordinate of the pointer, namely the tip of the stick, is determined.

$$(x-a_0)^2+(y-b_0)^2+(z-c_0)^2=l_0^2$$
$$(x-a_1)^2+(y-b_1)^2+(z-c_1)^2=l_1^2$$
$$(x-a_2)^2+(y-b_2)^2+(z-c_2)^2=l_2^2$$
$$(x-a_3)^2+(y-b_3)^2+(z-c_3)^2=l_3^2$$

The rotary encoder converts the variation of the string length into the coordinate of the pointer. To restrict the motion of the stick touching the virtual object generates the force and tactile sense.

In our system, to control the strings fixed to the tip of the stick generates the force and tactile sense.

5. System Description

Fig.8 suggested our Mixed Reality system.
Our system is composed by four parts, 3-D display, SPIDAR, Head-Tracking-System and Graphic-Workstation.
Graphic Workstation makes CG for both eyes.
The Head-Tracking-Sensor detects the viewpoint and Video-Switch-Circuit switches the right and left eye images to prevent pseudoscopic.
SPIDAR detects the position of the pointer and generate force and tactile sense.

SPIDAR makes it possible to interact the virtual object by the real object in our own hand.

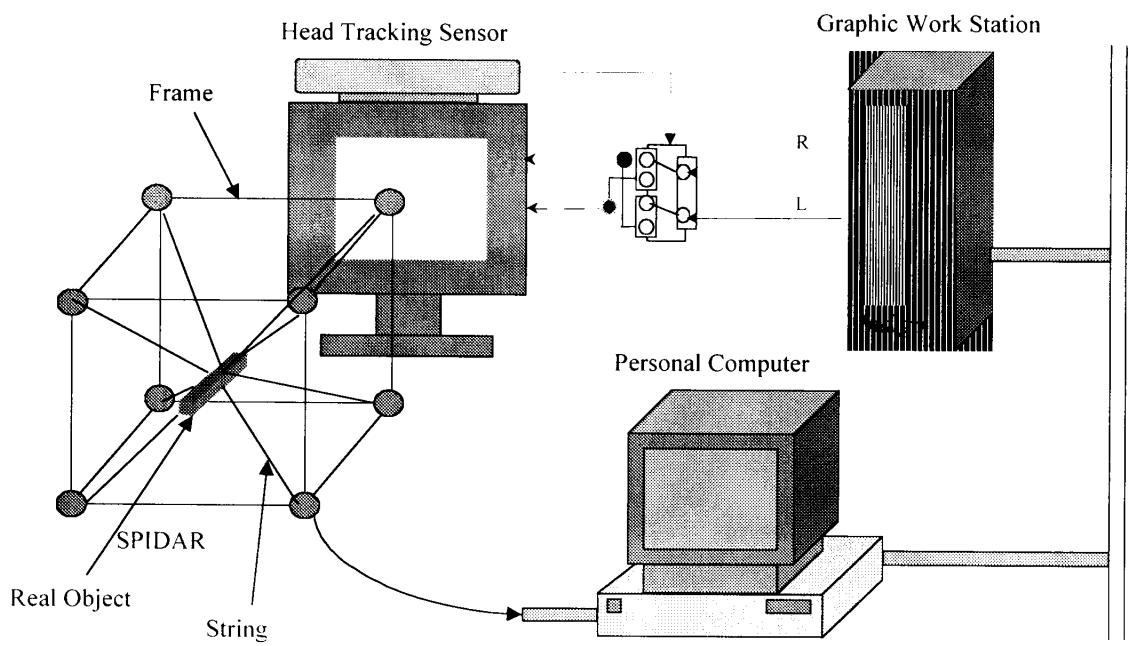

Fig. 8 MR system